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(54) MULTIPLEX TRANSMISSION SYSTEM AND BAND CONTROL METHOD

(57) A multiplex system for multiplexing packets into ATM cells to be transmitted, which can implement effective use of channels corresponding to irregular traffic qualities in services with various types of quality conditions in an actual environment. In response to a connection establishment request (S402), current required bandwidths B1, ..., Bm are changed to B'1, ..., B'm by adding the new connection, which causes bandwidths X1, ..., Xm which are assigned to the channels to be changed. When the desired bandwidth including the requested connection is less than an available bandwidth of the corresponding channel, an assigned bandwidth change processing (S406) is activated to assign new bandwidths in accordance with desired bandwidths. The bandwidth assignment change is carried out by changing ratios of extraction rates of packets from the buffers in the multiplex system.

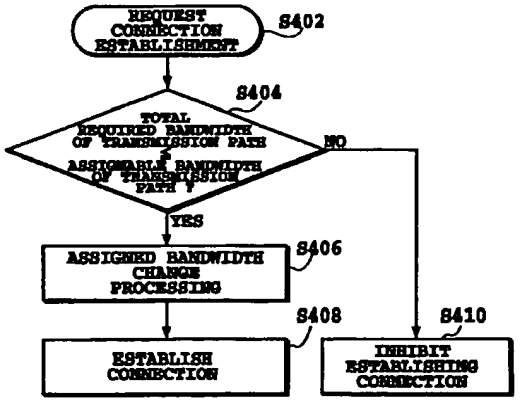

FIG.8

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Description

TECHNICAL FIELD

[0001] The present invention relates to ATM transmission, and more particularly to a bandwidth control method in the ATM transmission that can fulfill required service qualities in the transmission.

BACKGROUND ART

[0002] Generally, an ATM transmission system multiplexes cells with different quality conditions such as delay and a cell loss ratio, and transmits them through an output transmission path. To achieve such transmission, it is necessary for each quality class to have a plurality of buffers at a stage previous to the multiplexing.

[0003] The ATM transmission system also multiplexes packets with different quality conditions into ATM cells to be transmitted. To achieve such transmission, it is also necessary for each quality class to have a plurality of buffers at a stage previous to the multiplexing into the ATM cells.

[0004] Besides, there is an ATM transmission technique that multiplexes packets from a plurality of users into ATM cells to be transmitted. ATM adaptation layer type 2 (AAL type 2) can multiplex a maximum of 248 users into a single virtual channel (VC) connection to be transmitted. Since the quality class is usually required for each user connection, a plurality of quality classes must be prepared in the VC connection so that the transmission is carried out with the quality that meets the requirement of each user connection.

[0005] A system configuration for multiplexing packets consisting of a plurality of connections into ATM cells is disclosed, for example, in "Multiplex Transmitter for Micro-frame", an international application filed by the assignee of the present application (International Publication No. WO97/23975 published July 3, 1997). Its disclosure has a plurality of buffers for each quality class, distributes to the buffers packets input to the multiplex transmitter, and extracts the packets from the buffers in predetermined order, thereby achieving transmission according to the quality classes.

[0006] In this case, the bandwidth to be assigned to each quality class is decided from the rate of extracting the cells or packets from the buffers of each quality class, to which they are delivered. However, establishment of a requested user connection sometimes becomes impossible because of the limited bandwidth set for each quality class, even if the total bandwidth of the transmission path has some leeway.

[0007] As described above, a system configuration is already present which enables the transmission of different qualities by loading a plurality of buffers with packets with different quality conditions such as delay and cell loss ratios, and by multiplexing them into ATM cells, in which the bandwidth of the transmission path is allotted to respective quality classes.

[0008] Generally, bandwidth ratios of respective quality classes are determined from traffic qualities estimated at the start of the multiplex system, and the packets or cells are extracted at the rates that meet the determined bandwidth ratios. However, estimating actual traffic qualities is not easy, and hence it is not unlikely that the bandwidth required for transmission can exceed the bandwidth assigned to the current quality class even if there is some bandwidth margin in the transmission path in its entirety. Thus, the connection establishment request is rejected because of the limited assigned bandwidth which cannot satisfy the service quality needed for the transmission. However, if the established bandwidth ratios can be changed, the transmission that fulfills the service quality can be achieved, enabling more connections to be accepted with maintaining small delay and cell loss ratios.

DISCLOSURE OF THE INVENTION

[0009] It is therefore an object of the present invention is to implement efficient use of a transmission path in response to irregular traffic qualities of various types of services with different quality conditions in an actual environment by providing a multiplex system, which outputs multiplexed information to a transmission path, with bandwidth change control.

[0010] To accomplish the foregoing object, the present invention provides a multiplex transmission system for carrying out multiplex transmission of ATM cells, the multiplex transmission system comprising: separate buffers, each allotted to one of quality classes, wherein accepting separately in the buffers transmission contents from a plurality of connections; changing ratios of extraction rates from the buffers; and changing ratios of bandwidths to be assigned to channels of respective quality classes by changing the ratios of the extraction rates.

[0011] The transmission contents from a plurality of connections can consist of ATM cells or packets. In the case of packets, they are extracted from the buffers, and multiplexed into ATM cells to be output. The system can be configured as a combination of them.

[0012] Ratios of bandwidths assigned to channels associated with respective quality classes can be changed when a request is made for establishing a new connection.

[0013] In addition, the ratios of bandwidths assigned to channels associated with respective quality classes can be changed when a request is made for releasing a currently communicating connection.

[0014] The ratios of bandwidths assigned to channels associated with respective quality classes can be changed when a request is made for establishing a new connection, and a bandwidth which is required for a quality class associated with the new connection after adding the new connection exceeds a bandwidth which

has been assigned to the quality class associated with the new connection.

[0015] Furthermore, the ratios of bandwidths assigned to channels associated with respective quality classes can be changed when any one of cell loss ratios which are monitored for respective quality classes exceed a predetermined value.

[0016] The multiplex system with the foregoing configurations can implement the effective use of the transmission path.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

Fig. 1 is a diagram showing relationships between a virtual path connection, virtual channel connection and user connection;

Fig. 2 is a schematic diagram comparing required bandwidths for respective quality classes and assigned bandwidths actually assigned to channels for respective quality classes;

Fig. 3 is a block diagram showing a configuration of a multiplex system for multiplexing ATM cells to be transmitted through a transmission path;

Fig. 4 is a block diagram showing a configuration of a multiplex system for multiplexing packets into ATM cells to be transmitted through a transmission path;

Fig. 5 is a block diagram showing a configuration of a multiplex system for carrying out multiplexing of Fig. 3 and that of Fig. 4 at the same time;

Fig. 6 is a schematic diagram showing assigned bandwidths in the multiplex system of Fig. 5;

Fig. 7 is a diagram showing sequence of processings by a bandwidth managing controller and an extracting block;

Fig. 8 is a flowchart illustrating a processing of the bandwidth change control in a connection establishing operation;

Fig. 9 is a flowchart illustrating a processing of the bandwidth change control in a connection release operation;

Fig. 10 is a diagram showing required bandwidths before and after the connection establishment, and bandwidths that have already been assigned to the transmission path and bandwidths that are assigned after an assigned bandwidth change processing;

Fig. 11 is a flowchart illustrating another processing of the bandwidth change control in the connection establishing operation in another embodiment;

Fig. 12 is a diagram showing required bandwidths before and after the connection establishment, and bandwidths that have already been assigned to the channel and bandwidths that are assigned after the assigned bandwidth change processing;

Fig. 13 is a flowchart illustrating a connection accept processing in the connection establishment in a third embodiment; and

Fig. 14 is a diagram illustrating a process sequence from a cell loss ratio monitor to a bandwidth management controller for activating the bandwidth change processing.

BEST MODE FOR CARRYING OUT THE INVENTION

[0018] Embodiments of the present invention will now be described with reference to the accompanying drawings.

[0019] Fig. 1 is a diagram showing relationships between a virtual path connection (VP), virtual channel connections (VCs) and user connections. Virtual connections based on ATM cells are present in the virtual connections on a physical transmission path. The virtual connections can represent the user connections, or can multiplex packets constituting the user connections onto ATM cells consisting of the virtual connections to transmits the packets. In Fig. 1, a plurality of user connections are established on the virtual connections. The present invention dynamically controls the bandwidths of the user connections consisting of the virtual connections based on the ATM cells, and the bandwidths of the user connections based on packets multiplexed on the ATM cells, so that they fulfill the service qualities of respective levels.

[0020] Fig. 2 is a schematic diagram comparing required bandwidths for respective quality classes and assigned bandwidths actually allotted to a transmission path (virtual path connection and virtual channel connections) for respective quality classes. As shown in Fig. 2, if the sum total of the bandwidths B1-Bm required for the quality classes is less than the available bandwidth of the transmission path, the bandwidths assigned to the channels have a margin. Therefore, optimum bandwidth assignment can be achieved by dynamically controlling the bandwidth assignment to the channels. The multiplex system described below carries out the optimum bandwidth assignment.

[0021] Fig. 3 is a block diagram showing a configuration of a multiplex system 100 for multiplexing ATM cells constituting connections requiring different service qualities, and for transmitting them through a transmission path (virtual path connections).

[0022] Cells that are input to a multiplex system 100 through input connections 1-n 101 have their own quality conditions. These packets are delivered by a distributor 102 to buffers 104 in accordance with quality classes.

[0023] The buffers 104 have shared waiting times set in advance based on quality conditions for outputting the cells, thereby sequentially discarding packets that exceed allowed waiting times. A cell loss ratio monitor 103 has a function to monitor discard rates of the cells in the buffers 104. A bandwidth managing controller 150 decides, from the ratios of the bandwidths assigned to

the quality classes, optimum ratios of the extraction rates from the buffers, and supplies an extracting block 105 with extraction information that designates the buffer from which the cell is to be extracted. The extracting block 105 extracts the cell in accordance with the extraction information supplied. The ATM cell extracted is sent to an output channel 108 through a transmitting block 107.

[0024] Fig. 4 is a block diagram showing a configuration of a multiplex system 200 that multiplexes packets constituting different user connections into ATM cells constituting virtual channel connections to be transmitted.

[0025] Packets that are input to the multiplex system 200 through input connections 1-n 201 have their own quality conditions. These packets are delivered by a distributor 202 to buffers 204 in accordance with quality classes.

[0026] The buffers 204 have shared waiting times set in advance based on quality conditions for multiplexing the packets, thereby sequentially discarding packets that exceed allowed waiting times. A bandwidth managing controller 250 has a function to monitor discard rates of the packets in the buffers 204. A bandwidth managing controller 250 decides, from the ratios of the bandwidths assigned to the quality classes, optimum ratios of the extraction rates from the buffers, and supplies an extracting block 205 with extraction information that designates the buffer from which the packets are to be extracted. The extracting block 205 extracts the packets in accordance with the extraction information supplied, and a multiplex processing unit 206 multiplexes the extracted packets into the ATM cells. The ATM cells multiplexed are sent to an output channel 208 through a transmitting block 207.

[0027] Fig. 5 is a block diagram showing a configuration of a multiplex system 300 for carrying out the multiplexing of Figs. 3 and 4 at the same time, and Fig. 6 is a schematic diagram showing assigned bandwidths in the multiplex system of Fig. 5. In Fig. 5, the blocks designated by the same reference numerals as those of Figs. 3 and 4 have the same functions.

[0028] In Fig. 5, the user connections 101 constitute connections for ATM cells, and the packets supplied from the user connections 201 are multiplexed through the distributor 202, buffers 204, extracting block 205 and multiplex processing unit 206 as described in connection with Fig. 4. The ATM cells into which the packets are multiplexed are stored in a buffer m+1 in buffers 304. The ATM cells stored in the buffer m+1 are extracted together with other ATM cells from the buffers 304 by the extracting block 105 at the ratios of the extraction rates corresponding to the assigned bandwidths. The ATM cells extracted are multiplexed with other ATM cells by a multiplex processing unit 306 as needed, and are output to an output channel 308 through a transmitting block 307.

[0029] In this case, a bandwidth managing controller 250 controls the ratios of the extraction rates of the packets from the buffers 204 such that the user channels have virtual channel (VC) bandwidths B1'-Bm' as illustrated in Fig. 6. In addition, a bandwidth managing controller 150 controls the ratios of the extraction rates of the ATM cells from the buffers 304 such that the ratios have virtual path connection (VP) bandwidths X1-Xm+1 as illustrated in Fig. 6.

[0030] Although the packets are multiplexed into the single virtual channel connection in Figs. 5 and 6, a configuration can be arranged in which the packets are multiplexed into a plurality of virtual channel connections. In this case, the components 201-206 and the buffer (m+1) are installed by the number of the virtual channel connections.

[0031] Fig. 7 is a diagram showing a sequence associated with the processings of the bandwidth managing controllers 150 and 250 and extracting blocks 105 and 205 in Figs. 3-5.

[0032] In Fig. 7, the bandwidth managing controllers 150 and 250 each manage the connections for respective quality classes (S302), determine the bandwidths (B1'-Bm' and B1-Bm) required for respective quality classes using conversion data or conversion algorithm prepared in advance (S304), and assign the required bandwidths decided as available bandwidths of the transmission path. The assigned bandwidths (X1-Xm) actually allotted to the transmission path usually have a bandwidth equal to or greater than the required one as shown in Figs. 2 and 6 to fulfill the quality conditions. The assigned bandwidth ratios are converted into the extraction information (S306). The extracting blocks 105 and 205 in the multiplex system each carry out the extraction in accordance with the extraction information sent from the bandwidth managing controller 150 (S308), thereby ensuring the bandwidths of the respective quality classes. This in turn ensures the quality of the connections or packets. The bandwidths thus ensured can be altered by changing the extraction information by the bandwidth managing controllers 150 and 250.

[0033] The bandwidth managing controllers 150 and 250 can be installed either outside the multiplex system (for example, in an ATM switching system), or inside the multiplex system. Alternatively, they can be separately placed inside and outside the multiplex system. In Figs. 3-5, they are positioned outside the multiplex system, and their functions as well as those of the multiplex system are implemented by computers (not shown).

[0034] Various types of control can be achieved in the multiplex systems 100, 200 and 300 as shown in Figs. 3-5 by varying the trigger of the bandwidth change processing. The control processing will now be described in the following control examples whose fundamental structures are those of Figs. 3-5.

(Control example 1)

[0035] Figs. 8-10 are diagrams illustrating the operation of the control example 1 which carries out the bandwidth change processing by the bandwidth managing controller 150 or 250 each time the connection is established.

[0036] Fig. 8 is a flowchart illustrating a processing of the bandwidth change control when establishing the connection, Fig. 9 is a flowchart illustrating a processing of the bandwidth change control when releasing the connection, and Fig. 10 is a diagram showing required bandwidths before and after the connection establishment, and bandwidths that have already been assigned to the channel and bandwidths assigned after the bandwidth change processing in the control example 1.

[0037] In Fig. 8, receiving a request for establishing a connection (S402), the bandwidth managing controller 150 calculates a total required bandwidth of the transmission path which is needed for the transmission after adding to the currently established connections the connection to be established according to the request. The bandwidth (bx) required for each connection can be decided from the quality conditions such as the maximum cell rate, sustainable cell rate, minimum cell rate, cell transfer delay, cell delay variation and cell loss ratio. The calculation method of the required bandwidths (B1-Bm) for respective quality classes can be one that sums up the required bandwidths for respective connections, or one that obtains them using conversion data or conversion algorithm between the connections and the required bandwidths considering the statistical multiplexing effect in making a plurality of connections. The total required bandwidth of the transmission path can be obtained as the sum total of the required bandwidths calculated for respective quality classes. The total required bandwidth of the transmission path is compared with the available bandwidth of the transmission path assignable to the transmission path (S404), and if the former does not exceed the latter, the bandwidths (X1-Xm) assigned to the quality classes are converted into the optimum bandwidth ratios (X'1-X'm) under the condition in which the new connection is added (S406). Thus, the requested connection is established (S408). Since the assigned bandwidths of the quality classes after the change are equal to or greater than the required bandwidths in this case, the service quality can be ensured of the established connection and currently communicating connections. If the total required bandwidth of the transmission path exceeds the available bandwidth, the connection establishment is rejected (S410) to ensure the service quality of the currently communicating connections.

[0038] In Fig. 9, receiving a request for releasing a connection (S502), the bandwidth managing controller 150 releases the transmission path associated with the connection release, and reassigns the bandwidth which has been assigned to the transmission path (S506).

[0039] Fig. 10 is a diagram showing as in Fig. 4 the required bandwidths before and after the connection establishment by the processing of Fig. 8, and bandwidths that have already been assigned to the transmission path and bandwidths assigned after the assigned bandwidth change processing.

[0040] In Fig. 10, in response to the connection establishment request in Fig. 8 (S402), the current required bandwidths B1, ..., Bm as shown in Fig. 10 are changed to the required bandwidths B'1, ..., B'm by adding the new connection. Thus, the currently assigned bandwidths X1, ..., Xm as shown in Fig. 10 are to be changed, and if the required bandwidth considering the requested connection is less than the available bandwidth of the transmission path, the assigned bandwidth change processing is activated (S406). Thus, the bandwidths after the change are assigned as shown in Fig. 10.

[0041] The control example 1 described above carries out the bandwidth change processing each time the connection is established. Although this enables the transmission using the optimum assigned bandwidths, the load of the processing can be reduced by carrying out the bandwidth change processing at intervals a predetermined number of connections are accepted or at every fixed interval. In this case, although the required bandwidths can temporarily exceed the assigned bandwidths, this does not necessarily lead to the degradation in the service quality because if no packet with the intended quality is present when extracting the packet from the buffer to the assigned band, a packet with other quality can be extracted instead.

[0042] The connection is released in response to the connection release request, and the assigned bandwidths are optimized by changing the assigned bandwidths of the quality classes to the optimum bandwidth ratios using the same calculating method as in the connection establishment.

(Control example 2)

[0043] The processing load can be reduced with maintaining the service quality by carrying out the bandwidth change processing or the calculation of the total required bandwidth of the transmission path only when the required bandwidth of the quality classes associated with the establishment requested connection exceeds the assigned bandwidth. Such processing is implemented in the control example 2, which will now be described in detail with reference to Figs. 11 and 12.

[0044] Fig. 11 is a flowchart illustrating a processing of the bandwidth change control when establishing the connection in the control example 2, and Fig. 12 is a diagram showing required bandwidths before and after the connection establishment, and bandwidths that have already been assigned to the channel and bandwidths that are allotted after the bandwidth change processing in the control example 2.

[0045] In Fig. 11, receiving a request for establishing a connection (S702), the bandwidth managing controller calculates a required bandwidth of the quality class of the connection after adding the connection to be established according to the request. The bandwidth (bx) needed for the connection can be decided from values reported at the connection establishment request such as the maximum cell rate, sustainable cell rate, minimum cell rate, cell transfer delay, cell delay variation and cell loss ratio.

[0046] The calculation method of the required bandwidths (B1-Bm) for respective quality classes can be one that sums up the bandwidths required for respective connections, or one that obtains them using conversion data or conversion algorithm between the connections and the required bandwidths considering the statistical multiplexing effect in making a plurality of connections. The required bandwidth (B'n) calculated is compared with the bandwidth (Xn) assigned to the transmission path for the instant quality class (S704), and if the former does not exceed the latter, the required connection is established (S708). Since the assigned bandwidth for each quality class is equal to or greater than the required bandwidth in this case, the service quality can be ensured of the established connection and currently communicating connections.

[0047] If the required bandwidth exceeds the assigned bandwidth, the bandwidth managing controller calculates the required bandwidths of the quality classes, and then the total required bandwidth of the transmission path. The total required bandwidth of the transmission path can be obtained as the sum total of the required bandwidths calculated for respective quality classes. The calculated total required bandwidth of the transmission path is compared with the available bandwidth of the transmission path assignable to the transmission path (S706), and if the former does not exceed the latter, the bandwidths (X1-Xm) assigned to the quality classes are converted into the optimum bandwidth ratios (X'1-X'm) when the new connection is added (S408). Since the bandwidths assigned to the quality classes after the change are equal to or greater than the required bandwidths in this case, the service quality can be ensured of the established connection and currently communicating connections. If the total required bandwidth of the transmission path exceeds the available bandwidth, the connection establishment is not permitted to ensure the service quality of the currently communicating connections.

[0048] Fig. 12 is a diagram showing, as Fig. 10, required bandwidths before and after the connection establishment, and bandwidths that have already been assigned to the transmission path and bandwidths that are assigned after the assigned bandwidth change processing of the control example 2.

[0049] In Fig. 12, it is assumed that the connection establishment request is directed to the quality class B1, for example (S702). As illustrated in Fig. 12, as for the quality class B1, the required bandwidth is nearly equal to the assigned bandwidth with little margin. However, there is a sufficient margin considering the other quality classes. Thus, the assigned bandwidth change processing is activated (S710) so that the bandwidth assignment is changed as illustrated in this figure.

[0050] Thus, the control example 2 can reduce the load of the processing with maintaining the service quality to be ensured by carrying out the bandwidth change processing or the calculation of the total required bandwidth of the transmission path only if the required bandwidth of the quality class associated with the establishment required connection exceeds the assigned bandwidth.

(Control example 3)

[0051] In the present control example 3, the bandwidth managing controller 150 or 250 carries out the bandwidth change processing only when the cell loss ratio monitor 103 or 203 makes a request to them. This enables the reduction of the processing load with maintaining the service quality to be ensured. The control example 3 will now be described in detail with reference to Figs. 13 and 14.

[0052] Fig. 13 is a flowchart illustrating a connection accept processing in the connection establishment carried out by the bandwidth managing controller 150 or 250, and Fig. 14 is a diagram illustrating a process sequence of the cell loss ratio monitor 103 or 203 and bandwidth managing controller 150 or 250 for activating the bandwidth change processing in the control example 3.

[0053] In Fig. 13, receiving a request for establishing a connection, the bandwidth managing controller 150 or 250 calculates the total required bandwidth of the transmission path after adding to the currently established connections the connection to be established according to the request. The bandwidth (bx) required for the connection can be determined from values reported at the connection establishment request such as the maximum cell rate, sustainable cell rate, minimum cell rate, cell transfer delay, cell delay variation and cell loss ratio. The calculation method of the required bandwidths (B1-Bm) for respective quality classes can be one that sums up the bandwidths required for respective connections, or one that obtains them using conversion data or conversion algorithm between the connections and the required bandwidths considering the statistical multiplexing effect in making a plurality of connections. The total required bandwidth of the transmission path can be obtained as the sum total of the required bandwidths calculated for respective quality classes. The calculated total required bandwidth of the transmission path is compared with the available bandwidth of the transmission path assignable to the transmission path (S904), and if the former does not exceed the latter, the requested connection is established (S906). If the total

required bandwidth of the transmission path exceeds the available bandwidth, the connection establishment is rejected (S908) to ensure the service quality of the currently communicating connections. The assignment change of the bandwidths is not carried out in the processing for the connection establishment request. The assigned bandwidth change processing will now be described with reference to Fig. 14.

[0054] In Fig. 14, the cell loss ratio monitor continually monitors the packet loss ratio of each buffer, and sends to the bandwidth managing controller the bandwidth change request if the packet loss ratio exceeds a predetermined threshold value (S1002). The threshold value is defined in connection with the service quality, and setting it less than the packet loss ratio of the service quality to be ensured makes it possible to ensure the service quality of the current connection. Receiving the bandwidth change request, the bandwidth managing controller calculates the required bandwidths of the respective quality classes, and changes the bandwidths assigned to the quality classes to the optimum bandwidth ratios (S1004).

[0055] As described above, the bandwidth managing controller carries out the bandwidth change processing only when the cell loss ratio monitor makes a request for the bandwidth change. This makes it possible to reduce the processing load with maintaining the service quality to be ensured.

INDUSTRIAL APPLICABILITY

[0056] As described above, the present invention makes it possible in ATM transmission, which accepts in a plurality of separate buffers cells or packets with different quality conditions such as a delay and cell loss ratio, to change the bandwidths for the quality classes to be assigned to the transmission path by varying the extraction rates of the cells or packets from the buffers to the respective quality classes, thereby coping with the irregular traffic qualities of the services with various types of quality conditions in an actual environment.

[0057] Furthermore, it is always possible to assign the optimum bandwidth by changing the assigned bandwidths when establishing or releasing the user connection. It is also possible to reduce the load of the control processing with maintaining the service quality of the communications by changing the bandwidths only when the required bandwidth exceeds the bandwidth assigned to the quality class associated with the connection to be established. Moreover, the load of the control processing for changing the bandwidth can be further reduced with maintaining the service qualities of the communications by carrying out the bandwidth change processing at least when the cell or packet loss ratio exceeds the fixed threshold value while monitoring the actual cell or packet loss ratio.

Claims

1. A multiplex transmission system for carrying out multiplex transmission of ATM cells, said multiplex transmission system characterized by comprising:

   separate buffers, each allotted to one of quality classes, wherein
   accepting separately in said buffers transmission contents from a plurality of connections;
   changing ratios of extraction rates from said buffers; and
   changing ratios of bandwidths to be assigned to channels of respective quality classes by changing the ratios of the extraction rates.

2. The multiplex transmission system as claimed in claim 1, characterized in that said transmission contents from a plurality of connections consists of ATM cells.

3. The multiplex transmission system as claimed in claim 1, characterized in that said transmission contents from a plurality of connections consist of packets, and packets are extracted from said buffers to be multiplexed into ATM cells to be output.

4. The multiplex transmission system as claimed in claim 1, characterized in that said transmission contents from a plurality of connections consist of ATM cells and packets, and characterized in that

   said ATM cells and packets have their corresponding buffers;
   said packets are multiplexed to ATM cells to be output; and
   said ATM cells and packets are extracted from their corresponding buffers at ratios of independent extraction rates.

5. The multiplex transmission system as claimed in any one of claims 1-4, characterized in that ratios of bandwidths assigned to channels associated with respective quality classes are changed when a request is made for establishing a new connection.

6. The multiplex transmission system as claimed in any one of claims 1-4, characterized in that ratios of bandwidths assigned to channels associated with respective quality classes are changed when a request is made for releasing a currently communicating connection.

7. The multiplex transmission system as claimed in any one of claims 1-6, characterized in that ratios of bandwidths assigned to channels associated with respective quality classes are changed when a request is made for establishing a new connection,

and a bandwidth which is required for a quality class associated with the new connection after adding the new connection exceeds a bandwidth which has been assigned to the quality class associated with the new connection.

8. The multiplex transmission system as claimed in any one of claims 1-6, characterized in that ratios of bandwidths assigned to channels associated with respective quality classes are changed when any one of cell loss ratios which are monitored for respective quality classes exceed a predetermined value.

9. A bandwidth control method in a multiplex transmission system for carrying out multiplex transmission of ATM cells, said bandwidth control method characterized by comprising the steps of:

accepting in separate buffers transmission contents from a plurality of connections that differ from quality class to quality class;
changing ratios of extraction rates from said buffers; and
changing ratios of bandwidths to be assigned to channels of respective quality classes by changing the ratios of the extraction rates.

10. The bandwidth control method as claimed in claim 9, characterized in that said transmission contents from a plurality of connections consists of ATM cells.

11. The bandwidth control method as claimed in claim 9, characterized in that said transmission contents from a plurality of connections consist of packets, and packets are extracted from said buffers to be multiplexed into ATM cells to be output.

12. The bandwidth control method as claimed in claim 9, wherein said transmission contents from a plurality of connections consist of ATM cells and packets, and wherein

said ATM cells and packets are output to their corresponding buffers;
said packets are multiplexed to ATM cells to be output; and
said ATM cells and packets are extracted from their corresponding buffers at ratios of independent extraction rates.

13. The bandwidth control method as claimed in any one of claims 9-12, characterized in that ratios of bandwidths assigned to channels associated with respective quality classes are changed when a request is made for establishing a new connection.

14. The bandwidth control method as claimed in any one of claims 9-12, characterized in that ratios of bandwidths assigned to channels associated with respective quality classes are changed when a request is made for releasing a currently communicating connection.

15. The bandwidth control method as claimed in any one of claims 9-12, characterized in that ratios of bandwidths assigned to channels associated with respective quality classes are changed when a request is made for establishing a new connection, and a bandwidth which is required for a quality class associated with the new connection after adding the new connection exceeds a bandwidth which has been assigned to the quality class associated with the new connection.

16. The packet bandwidth control method as claimed in any one of claims 9-12, characterized in that ratios of bandwidths assigned to channels associated with respective quality classes are changed when any one of cell loss ratios which are monitored for respective quality classes exceed a predetermined value.

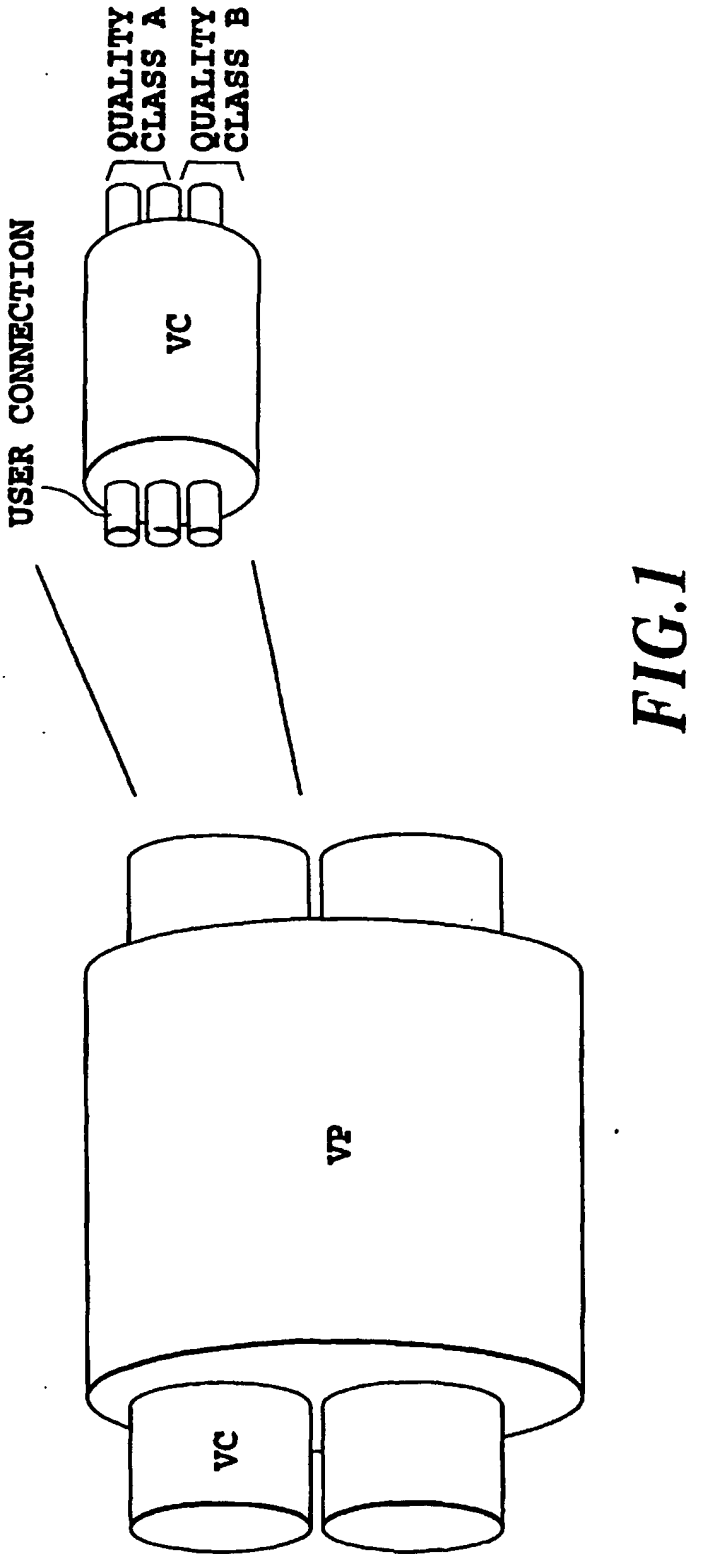


FIG.1

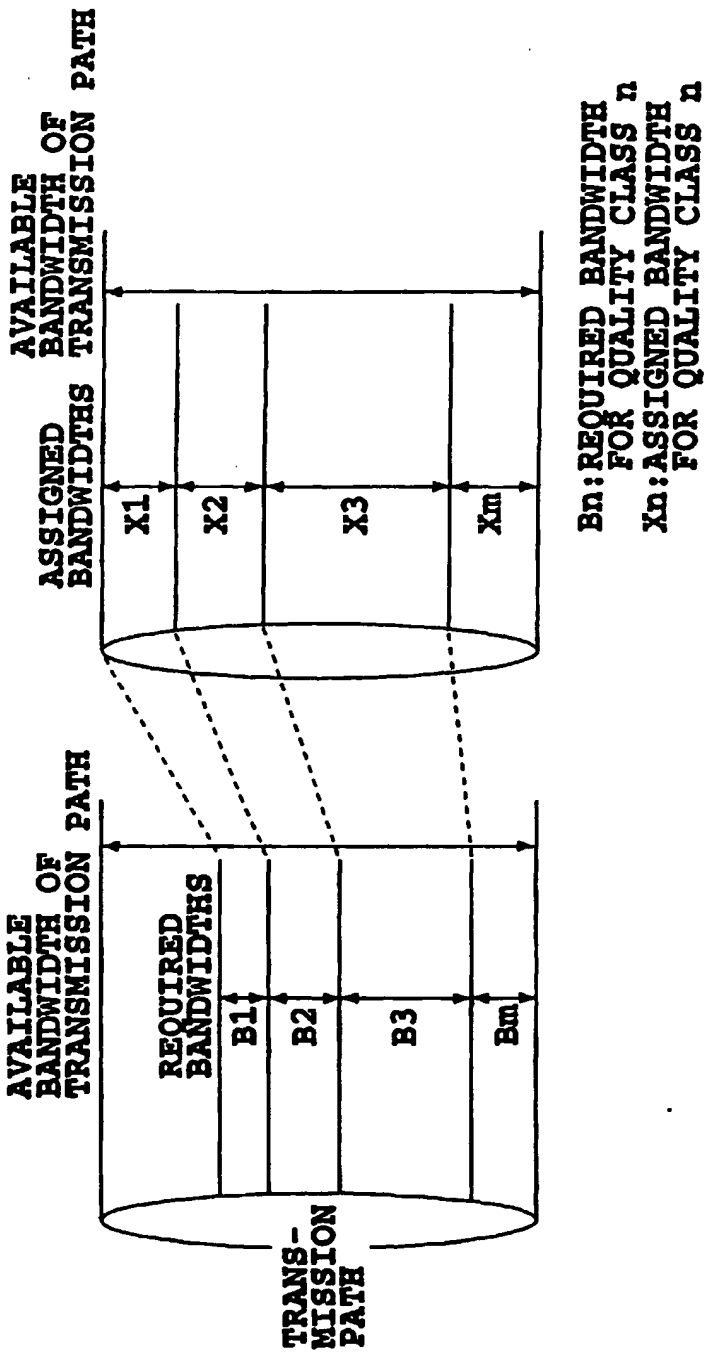

AVAILABLE BANDWIDTH OF TRANSMISSION PATH
ASSIGNED BANDWIDTHS
X1
X2
X3
Xm
Bn:REQUIRED BANDWIDTH FOR QUALITY CLASS n
Xn:ASSIGNED BANDWIDTH FOR QUALITY CLASS n
AVAILABLE BANDWIDTH OF TRANSMISSION PATH
REQUIRED BANDWIDTHS
B1
B2
B3
Bm
TRANS-MISSION PATH

FIG.2

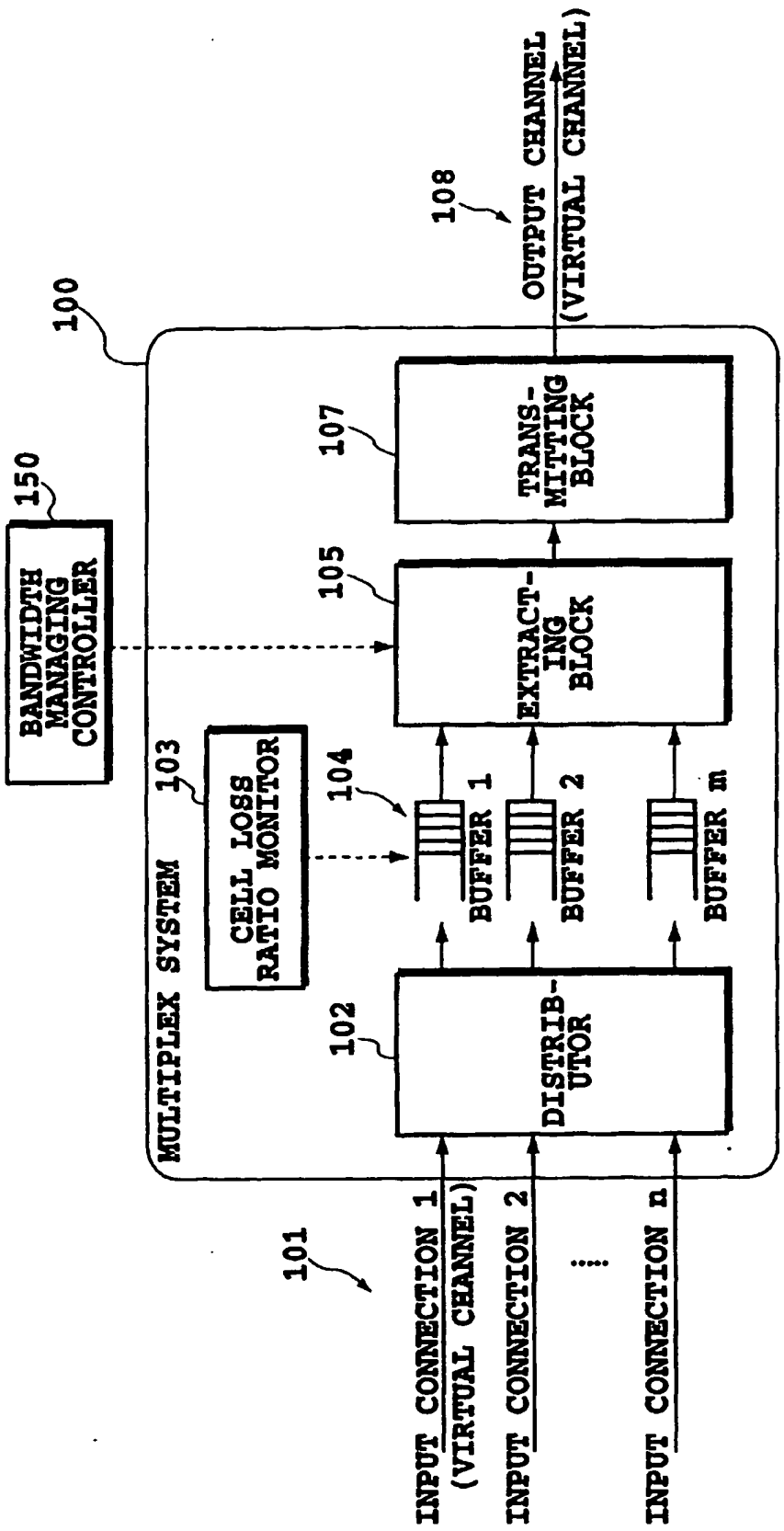

INPUT CONNECTION 1 (VIRTUAL CHANNEL)
INPUT CONNECTION 2
INPUT CONNECTION n
101
MULTIPLEX SYSTEM
100
DISTRIB-UTOR
102
CELL LOSS RATIO MONITOR
103
BUFFER 1
BUFFER 2
BUFFER m
104
EXTRACT-ING BLOCK
105
TRANS-MITTING BLOCK
107
OUTPUT CHANNEL (VIRTUAL CHANNEL)
108
BANDWIDTH MANAGING CONTROLLER
150

FIG.3

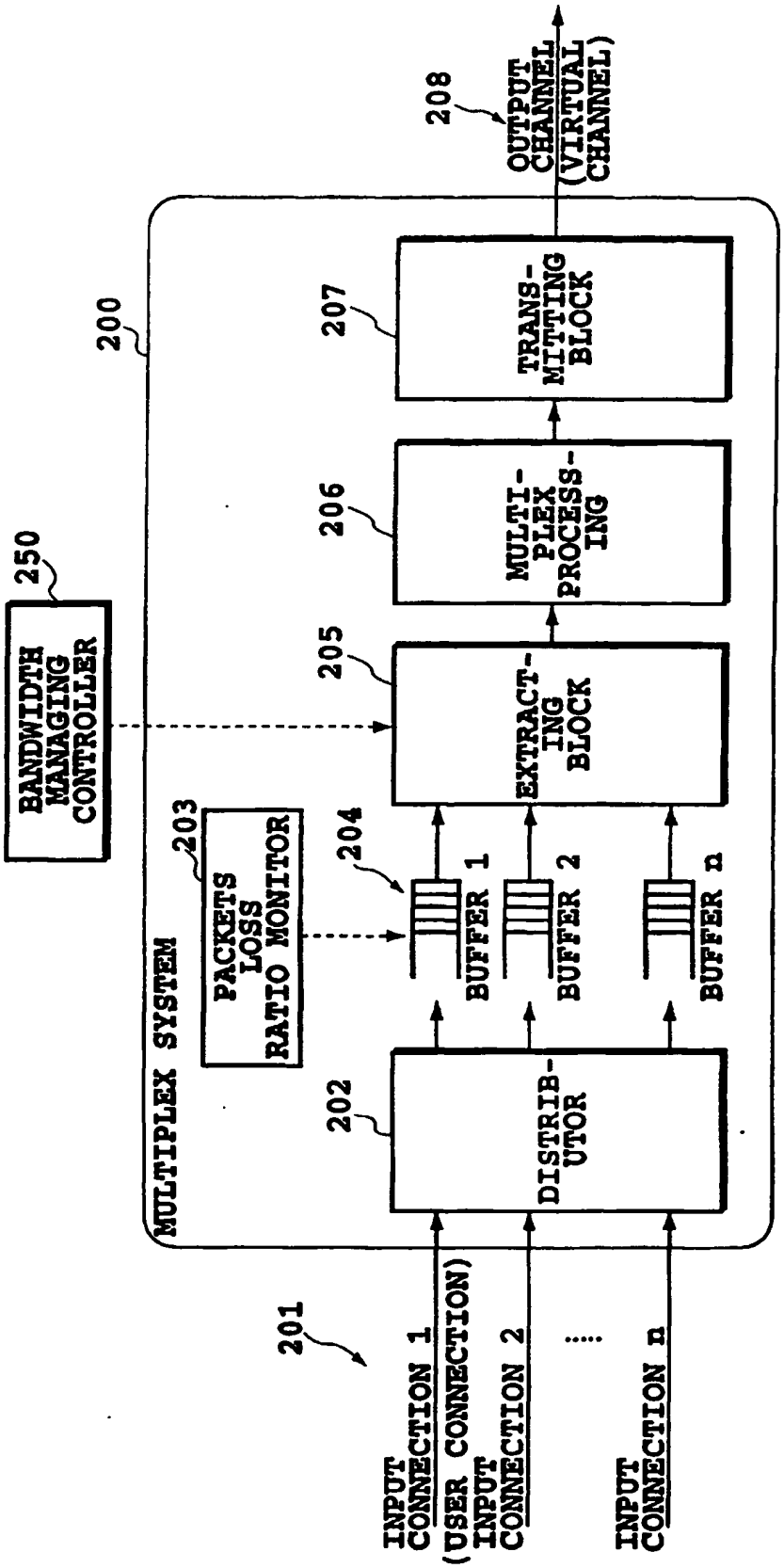

208
OUTPUT CHANNEL (VIRTUAL CHANNEL)
200
207
TRANS-MITTING BLOCK
206
MULTI-PLEX PROCESS-ING
250
BANDWIDTH MANAGING CONTROLLER
205
EXTRACT-ING BLOCK
203
PACKETS LOSS RATIO MONITOR
204
BUFFER 1
BUFFER 2
BUFFER n
MULTIPLEX SYSTEM
202
DISTRIB-UTOR
201
INPUT CONNECTION 1 (USER CONNECTION)
INPUT CONNECTION 2
....
INPUT CONNECTION n

FIG.4

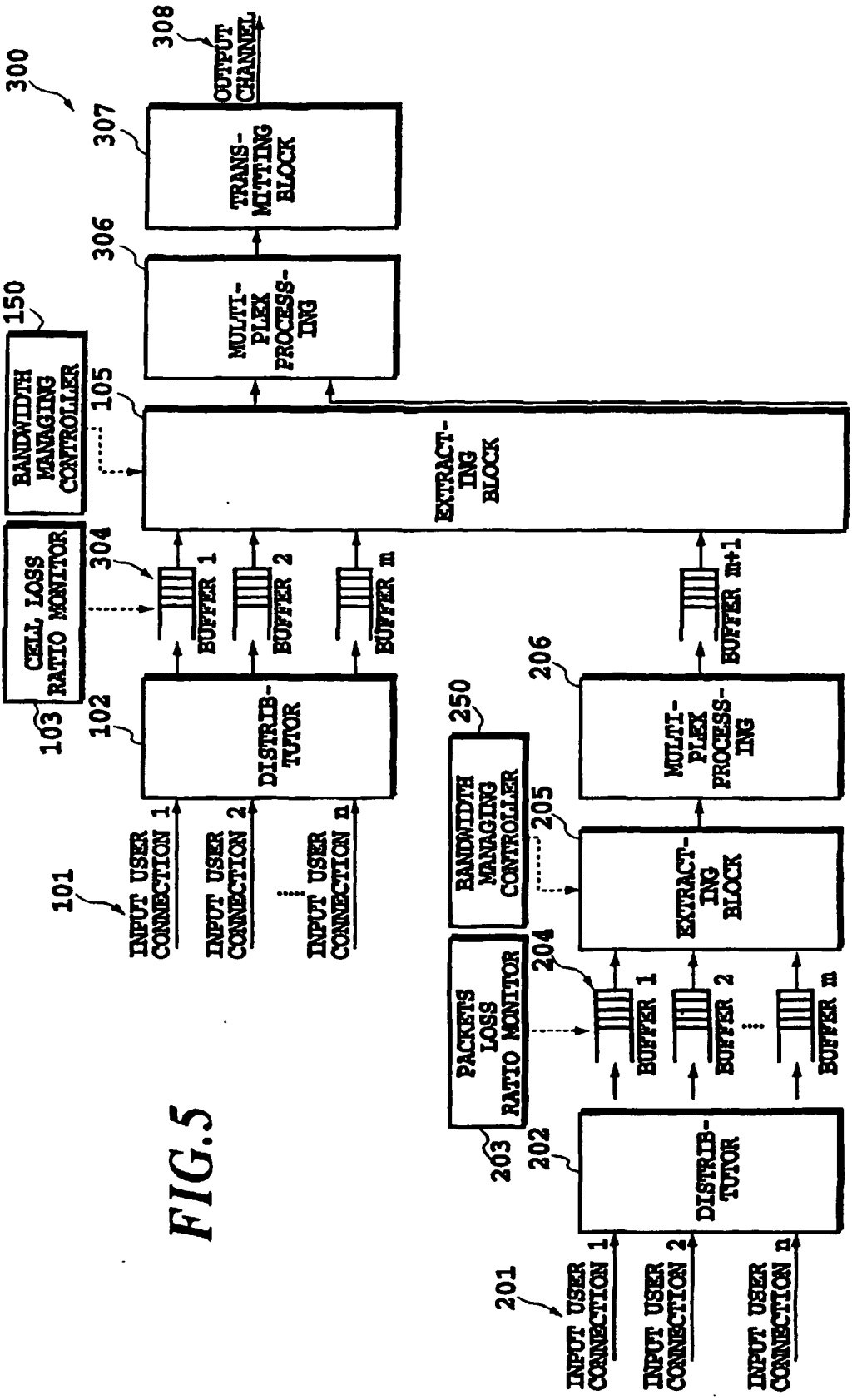

300
308
OUTPUT CHANNEL
307
TRANS-MITTING BLOCK
306
MULTI-PLEX PROCESS-ING
150
BANDWIDTH MANAGING CONTROLLER
105
EXTRACT-ING BLOCK
CELL LOSS RATIO MONITOR
304
BUFFER 1
BUFFER 2
BUFFER m
BUFFER m+1
103
102
DISTRIB-TUTOR
250
206
MULTI-PLEX PROCESS-ING
BANDWIDTH MANAGING CONTROLLER
205
EXTRACT-ING BLOCK
101
INPUT USER CONNECTION 1
INPUT USER CONNECTION 2
INPUT USER CONNECTION n
PACKETS LOSS RATIO MONITOR
204
BUFFER 1
BUFFER 2
BUFFER m
203
202
DISTRIB-TUTOR
201
INPUT USER CONNECTION 1
INPUT USER CONNECTION 2
INPUT USER CONNECTION n

FIG.5

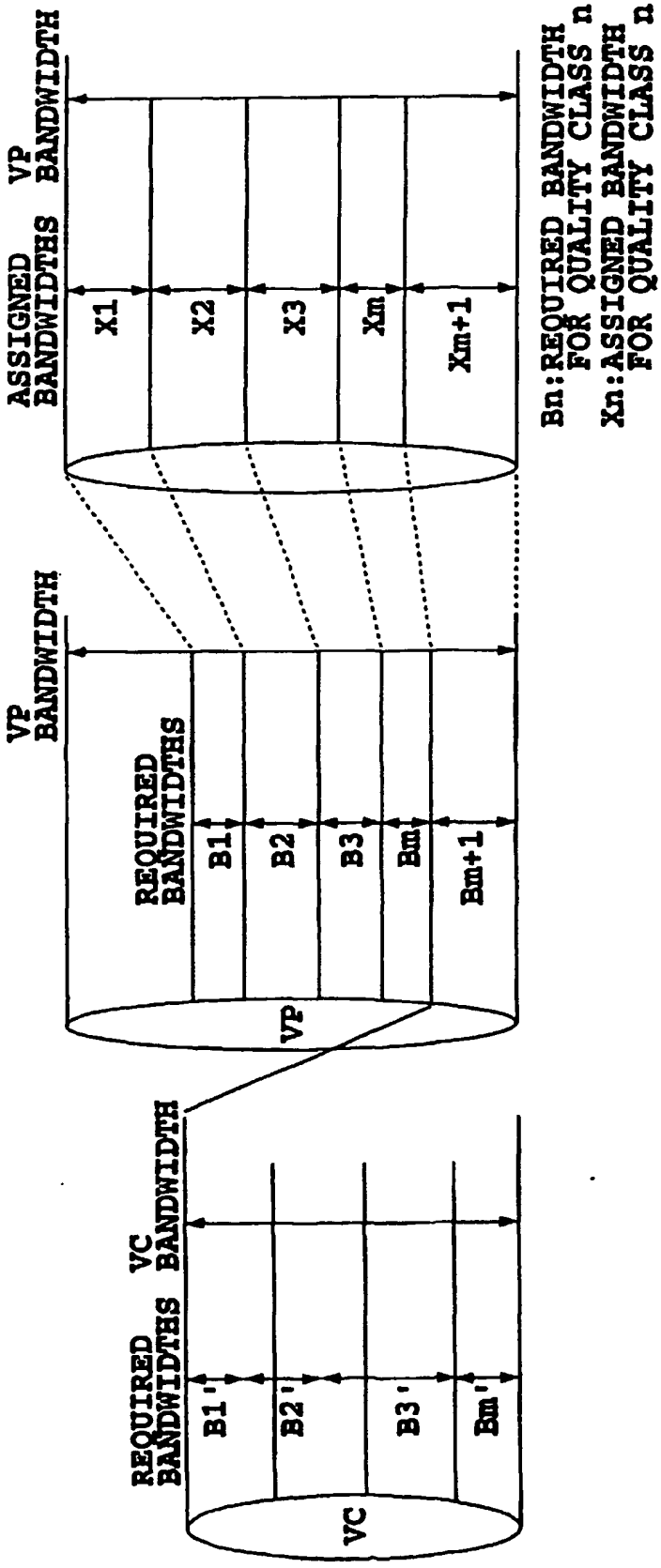

VP BANDWIDTH
ASSIGNED BANDWIDTHS
X1
X2
X3
Xm
Xm+1
Bn:REQUIRED BANDWIDTH FOR QUALITY CLASS n
Xn:ASSIGNED BANDWIDTH FOR QUALITY CLASS n
VP BANDWIDTH
REQUIRED BANDWIDTHS
B1
B2
B3
Bm
Bm+1
VP
VC BANDWIDTH
REQUIRED BANDWIDTHS
B1'
B2'
B3'
Bm'
VC

FIG.6

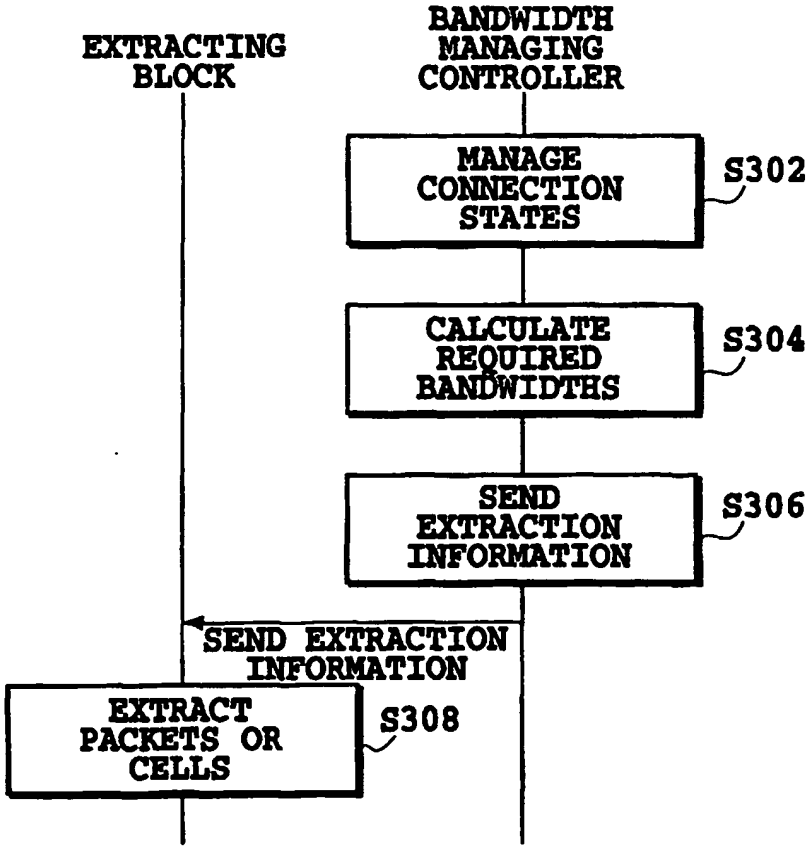

EXTRACTING BLOCK
BANDWIDTH MANAGING CONTROLLER
MANAGE CONNECTION STATES
S302
CALCULATE REQUIRED BANDWIDTHS
S304
SEND EXTRACTION INFORMATION
S306
SEND EXTRACTION INFORMATION
EXTRACT PACKETS OR CELLS
S308

FIG.7

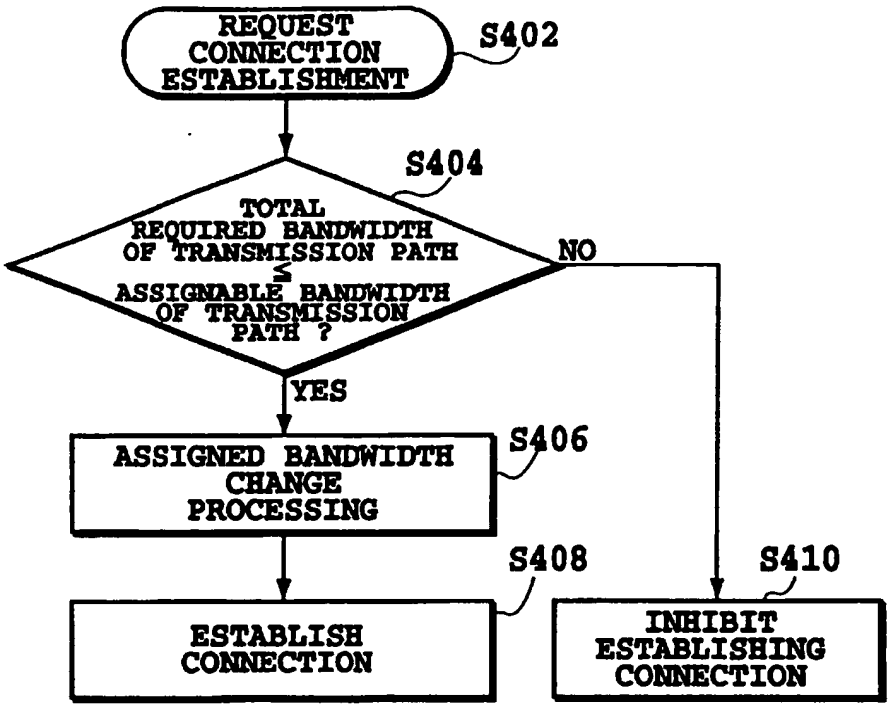

REQUEST CONNECTION ESTABLISHMENT
S402
S404
TOTAL REQUIRED BANDWIDTH OF TRANSMISSION PATH ≤ ASSIGNABLE BANDWIDTH OF TRANSMISSION PATH ?
NO
YES
ASSIGNED BANDWIDTH CHANGE PROCESSING
S406
S408
ESTABLISH CONNECTION
S410
INHIBIT ESTABLISHING CONNECTION

FIG.8

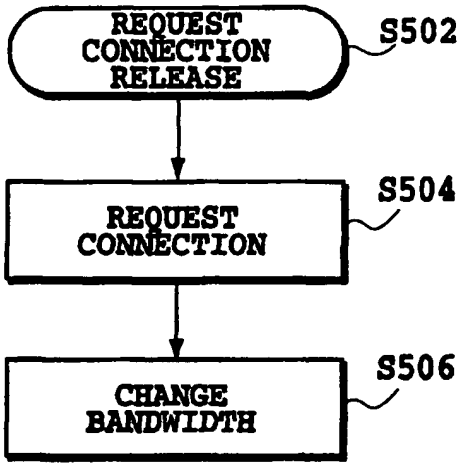

REQUEST CONNECTION RELEASE
S502
REQUEST CONNECTION
S504
CHANGE BANDWIDTH
S506

FIG.9

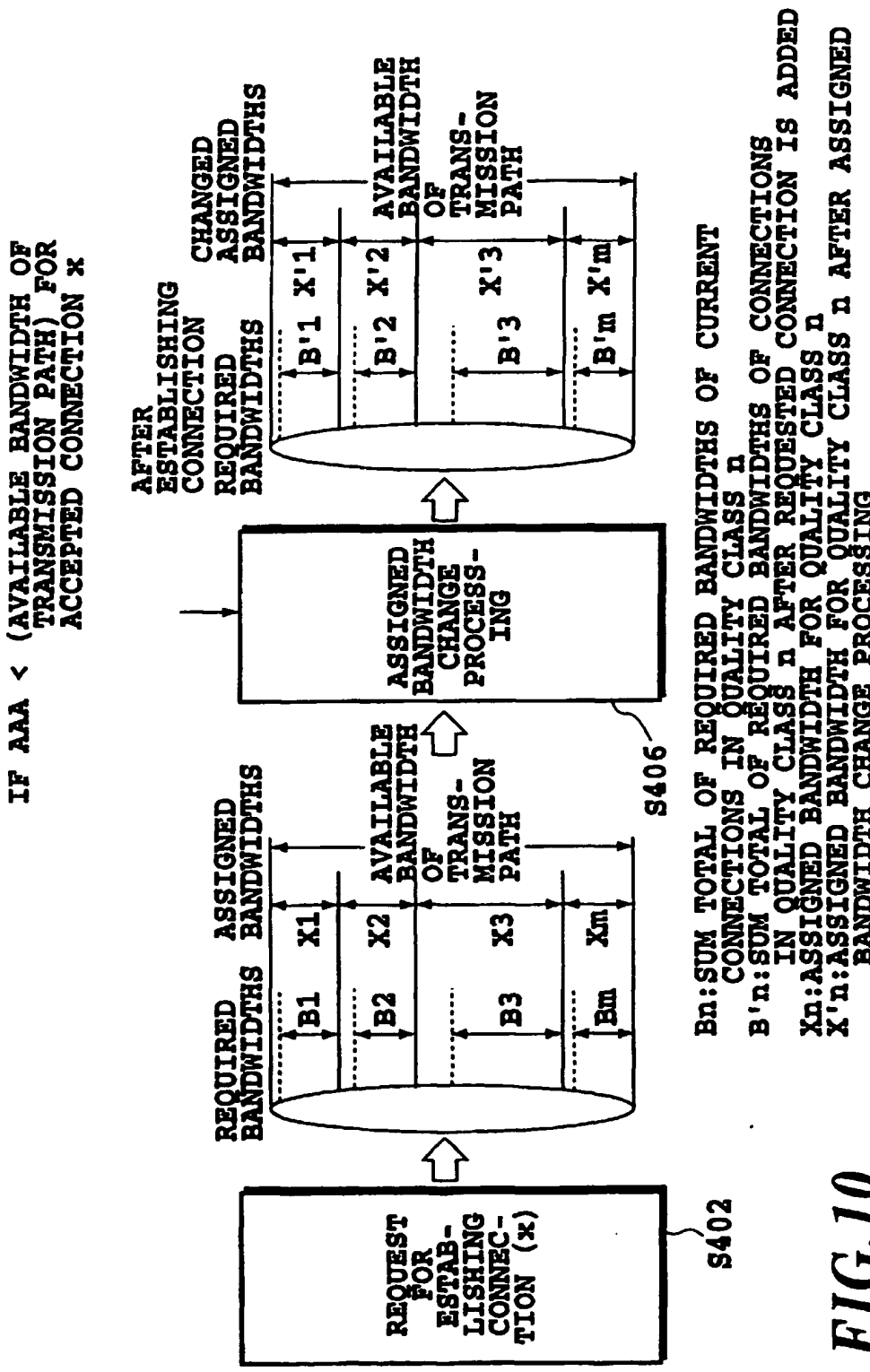

IF AAA < (AVAILABLE BANDWIDTH OF TRANSMISSION PATH) FOR ACCEPTED CONNECTION x
REQUEST FOR ESTAB-LISHING CONNEC-TION (x)
S402
REQUIRED BANDWIDTHS
ASSIGNED BANDWIDTHS
B1
X1
B2
X2
B3
X3
Bm
Xm
AVAILABLE BANDWIDTH OF TRANS-MISSION PATH
S406
ASSIGNED BANDWIDTH CHANGE PROCESS-ING
AFTER ESTABLISHING CONNECTION
REQUIRED BANDWIDTHS
CHANGED ASSIGNED BANDWIDTHS
B'1
X'1
B'2
X'2
B'3
X'3
B'm
X'm
AVAILABLE BANDWIDTH OF TRANS-MISSION PATH
Bn:SUM TOTAL OF REQUIRED BANDWIDTHS OF CURRENT CONNECTIONS IN QUALITY CLASS n
B'n:SUM TOTAL OF REQUIRED BANDWIDTHS OF CONNECTIONS IN QUALITY CLASS n AFTER REQUESTED CONNECTION IS ADDED
Xn:ASSIGNED BANDWIDTH FOR QUALITY CLASS n
X'n:ASSIGNED BANDWIDTH FOR QUALITY CLASS n AFTER ASSIGNED BANDWIDTH CHANGE PROCESSING
bx:REQUIRED BANDWIDTH OF CONNECTION x

FIG.10

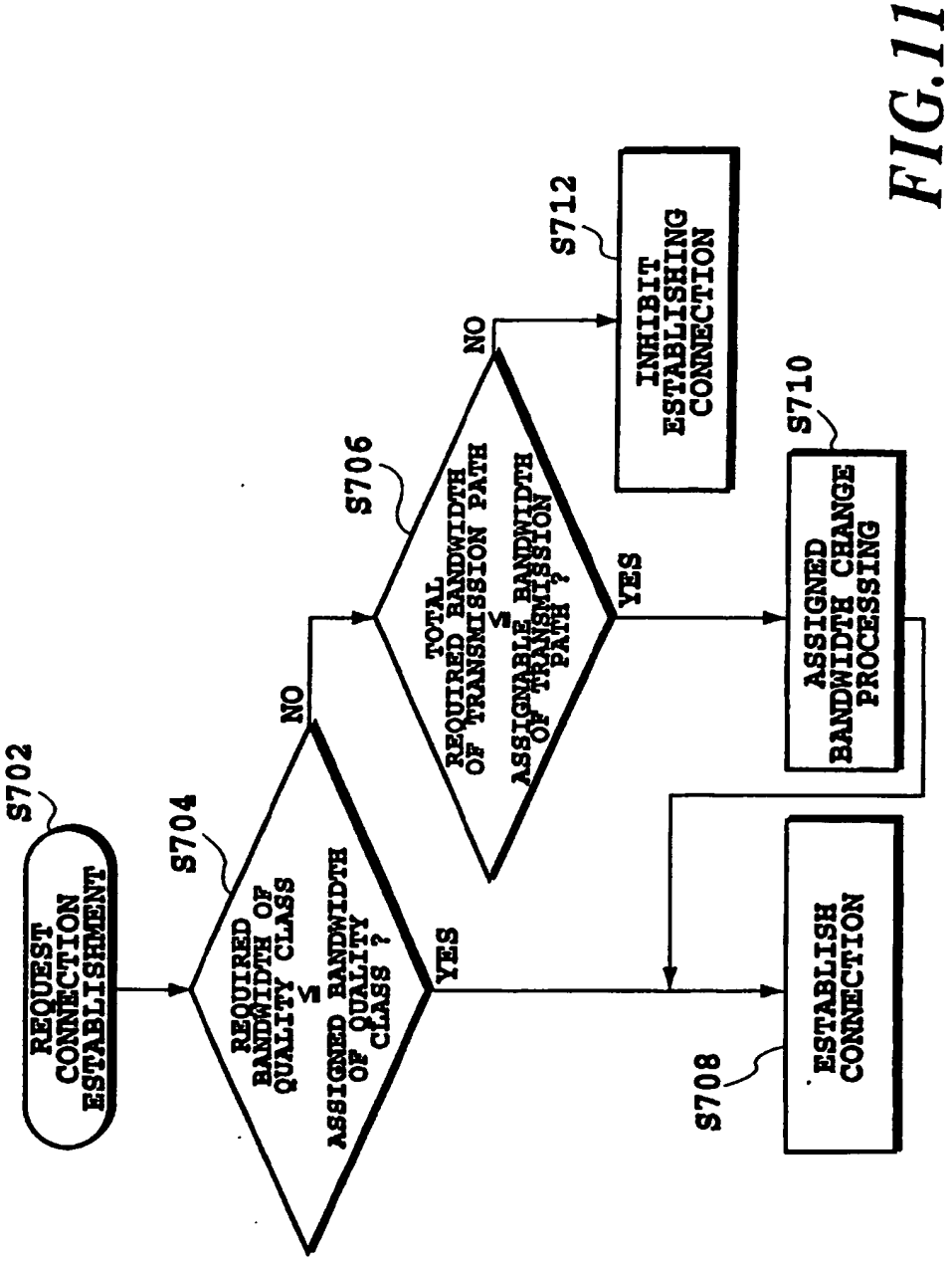
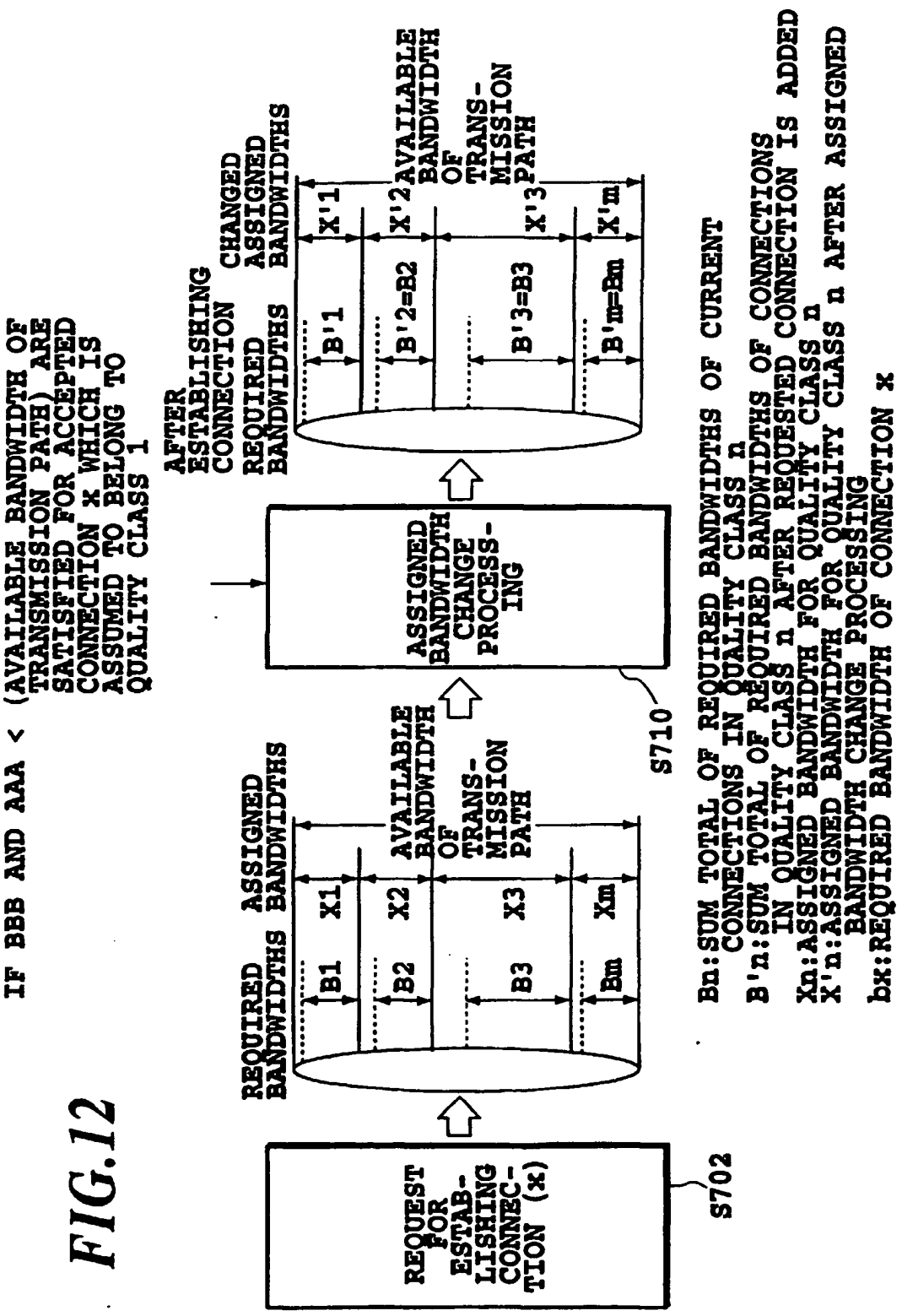

S702
REQUEST CONNECTION ESTABLISHMENT
S704
REQUIRED BANDWIDTH OF QUALITY CLASS ≤ ASSIGNED BANDWIDTH OF QUALITY CLASS ?
NO
YES
S706
TOTAL REQUIRED BANDWIDTH OF TRANSMISSION PATH ≤ ASSIGNABLE BANDWIDTH OF TRANSMISSION PATH ?
NO
YES
S708
ESTABLISH CONNECTION
S710
ASSIGNED BANDWIDTH CHANGE PROCESSING
S712
INHIBIT ESTABLISHING CONNECTION

FIG.11

FIG.12


IF BBB AND AAA < (AVAILABLE BANDWIDTH OF TRANSMISSION PATH) ARE SATISFIED FOR ACCEPTED CONNECTION x WHICH IS ASSUMED TO BELONG TO QUALITY CLASS 1
REQUEST FOR ESTAB-LISHING CONNEC-TION (x)
S702
REQUIRED BANDWIDTHS
ASSIGNED BANDWIDTHS
B1
X1
B2
X2
B3
X3
Bm
Xm
AVAILABLE BANDWIDTH OF TRANS-MISSION PATH
ASSIGNED BANDWIDTH CHANGE PROCESS-ING
S710
AFTER ESTABLISHING CONNECTION
REQUIRED BANDWIDTHS
CHANGED ASSIGNED BANDWIDTHS
B'1
B'2=B2
B'3=B3
B'm=Bm
X'1
X'2
X'3
X'm
AVAILABLE BANDWIDTH OF TRANS-MISSION PATH
Bn:SUM TOTAL OF REQUIRED BANDWIDTHS OF CURRENT CONNECTIONS IN QUALITY CLASS n
B'n:SUM TOTAL OF REQUIRED BANDWIDTHS OF CONNECTIONS IN QUALITY CLASS n AFTER REQUESTED CONNECTION IS ADDED
Xn:ASSIGNED BANDWIDTH FOR QUALITY CLASS n
X'n:ASSIGNED BANDWIDTH FOR QUALITY CLASS n AFTER ASSIGNED BANDWIDTH CHANGE PROCESSING
bx:REQUIRED BANDWIDTH OF CONNECTION x

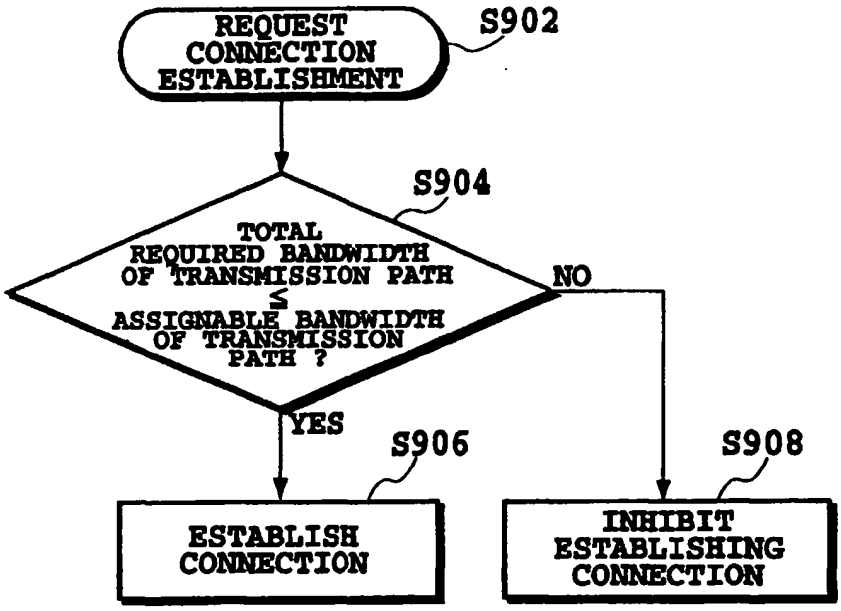

REQUEST CONNECTION ESTABLISHMENT
S902
S904
TOTAL REQUIRED BANDWIDTH OF TRANSMISSION PATH ≤ ASSIGNABLE BANDWIDTH OF TRANSMISSION PATH ?
NO
YES
S906
S908
ESTABLISH CONNECTION
INHIBIT ESTABLISHING CONNECTION

FIG.13

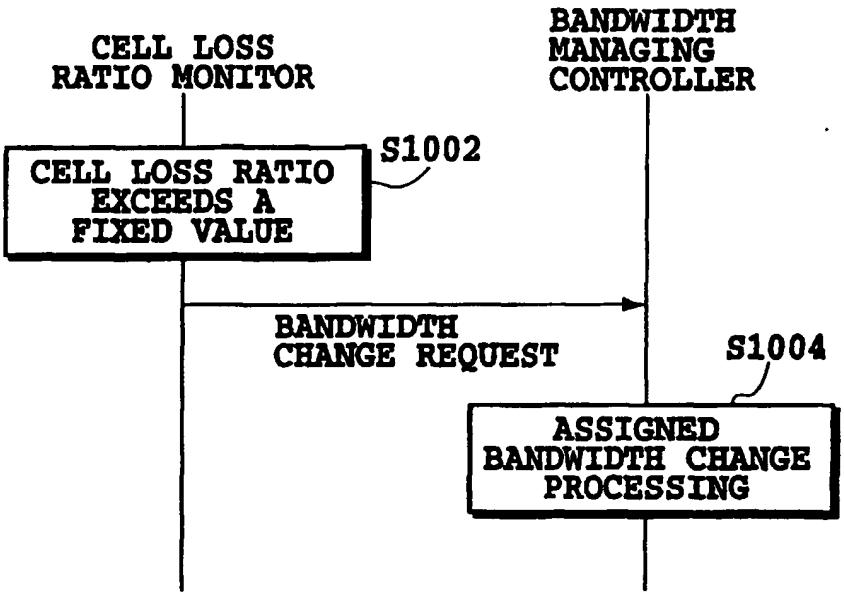

CELL LOSS
RATIO MONITOR
BANDWIDTH
MANAGING
CONTROLLER
CELL LOSS RATIO
EXCEEDS A
FIXED VALUE
S1002
BANDWIDTH
CHANGE REQUEST
S1004
ASSIGNED
BANDWIDTH CHANGE
PROCESSING

FIG.14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP98/03279

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[6] H04L12/56

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[6] H04L12/56, 12/28

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Technical Research Report of IEICE SSE (1995-1998), IN (1995-1998), CQ (1996-1998)
Papers from Annual Meeting of IEICE (1995-1998)
Papers from Communication Society Conversation of IEICE (1995-1997)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP, 5-3488, A (Mitsubishi Electric Corp.), 8 January, 1993 (08. 01. 93) & JP, 2780537, B2	1, 2, 5-7, 9, 10, 13-15
Y		3, 4, 11, 12
X	JP, 6-104917, A (Hitachi, Ltd.),	1, 2, 9, 10
Y	15 April, 1994 (15. 04. 94) (Family: none)	3, 4, 11, 12
A		8, 16
X	Technical Research Report of IEICE SSE95-59, 28 September, 1995, IEICE, T. Soumiya et al., "A Quality Control in the ATM Switching System"	1, 9
Y	1997 Annual Meeting of IEICE, 6 March, 1997, IEICE B-5-209 H. Kawakami et al., "Control ensuring bandwidth using AAL type 2 for mobile ATM network"	3, 4, 11, 12

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 October, 1998 (12. 10. 98)	20 October, 1998 (20. 10. 98)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP98/03279

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Technical Research Report of IEICE IN97-62 18 July, 1997, IEICE, H. Fujiya et al., "Realtime Voice Communications Over ATM"	3, 4, 11, 12
P, Y	1998 Annual Meeting of IEICE, 6 March, 1998, IEICE B-6-27 H. Ono et al., "A Study of mini cell multiplex method using AAL Type 2"	3, 4, 11, 12
E, X	JP, 10-200547, A (Fujitsu Ltd.), 31 July, 1998 (31. 07. 98) (Family: none)	1, 2, 5-7, 9, 10, 13-15

Form PCT/ISA/210 (continuation of second sheet) (July 1992)